Creative Destruction or Organizational Ineptitude: Explaining the Decline in the US Machine Tool Industry

Steve Onyeiwu
Department of Economics,
Allegheny College
Meadville, Pennsylvania 16335
USA
E-MAIL: sonyeiwu@allegheny.edu

Paper for Presentation at the DRUID Ten Years Anniversary Summer Conference, Copenhagen, CBS, Denmark, June 26-30, 2005. The research for this paper was supported by a grant from the Center for Economic and Environmental Development (CEED), Allegheny College. I wish to thank Katie Wheeler and Lauren Destefano for their very valuable research assistance.

Abstract

An interesting, and perhaps exasperating, issue about industrial dynamics is the question of why previously “vibrant” industries tend to decline over time. From textiles to semiconductors and consumer electronics, analysts have wondered why the United States has lost competitiveness in these previously vital industries. The latest “casualty” is the U.S. machine tool industry, where performance has been deteriorating inexorably. This paper explores the extent to which two competing paradigms – Creative Destruction and Organizational Ineptitude – explain the decline in the U.S. machine tool industry. The paper contends that, given the incremental and non-discrete nature of technical change in the machine tool industry, creative destruction has not been a problematic phenomenon in the industry in the U.S. Firms in the industry have effectively adopted and assimilated new digital-based production technologies, leaving organizational ineptitude as a plausible explanation for the industry’s decline. Based on a sample of over 60 firms in Northwestern Pennsylvania, the paper concludes that a preponderance of firms in the industry have failed to develop the organizational and managerial capabilities for responding to competitive pressures. The study confirms the Chandlerian notion that organizational deficiencies could circumscribe the ability of a firm to compete strategically and functionally with regard to development of new products, core competencies, and innovative management styles. Contrary to conventional wisdom, the tenacious adherence to “routines” and “path dependency” in the U.S. machine tool industry may have undermined the quest by U.S. tool shops for competitive advantage.

I. INTRODUCTION

The decline in the US machine tool industry that started several decades ago has continued unabated.[1] From a global leader in the production and export of tools, dies, and precision parts during the post World War II era, the United States is rapidly falling behind China, Canada, and Eastern European producers of tools and precision machines. From a net exporter of machine tools in 1975, the US became the world’s largest importer of machine tools by 1985, a position it still holds today (Forrant and Flynn, 1999, p.168). Starr and Ullmann (1988, pp. 58-59) poignantly describe this dire situation thus:

> Both the British and American machine tool industries had achieved a global supremacy of a most remarkable sort. Until

[1] The machine tools industry covers a wide array of activities, including precision manufacturing, tool and die, stamping, molding and plating.

> about 1960 it was difficult to find a large machine shop anywhere where the famous name-plates of the British and American makers could not be found; for certain major machines, American and British manufacturers were virtually the only game in town. Now the British industry is almost gone, and the American one survives only in vestigial form.

Despite recent gains in manufacturing productivity, and the access of U.S. machine tool shops to cutting-edge technology, the industry has continued to falter.[2] In the tool and die segment of the industry, for instance, net sales plummeted from $1.7 billion in 1999 to $1.5 billion in 2001, a fall of almost 12 percent. In 2002, sales fell further by more than 20 percent. Gross profit for the industry also fell by 26 percent, from $369.5 million in 1999 to $274.1 million in 2001.[3] Between 2001 and 2003, one in five members of the National Tooling and Machining Association (NTMA) left the association, mainly because their businesses failed. During the same period, 35,700 jobs were lost in the tooling industry.[4] The NTMA also claims that over 4,000 out of the roughly 14,000 tool shops in the country liquidated during the past few years, amounting to a closure rate of 28.6 percent.

Why, then, has the machine tool industry continued to deteriorate, despite productivity gains and access to new vintages of production equipment? Could the waning of the competitive abilities of US tool shops be attributed to "creative destruction" that has provided them access to new technologies, but at the same time

---

[2] Output per worker in industrial machinery and equipment increased at a 7.9 percent annual rate in the 1990s and electronic and other electric equipment at 13.9 percent (Sharpe, 1999, p.4). Productivity growth in these two sectors accounted for a whopping 102.9 percent of the overall output increases in the US manufacturing sector (Sharpe, 1999, p.4).

[3] Because of the poor performance of the industry, the Ways and Means Committee of the U.S. House of Representatives mandated the ITC to investigate allegations that foreign competition, particularly from China, was responsible for the industry's problems. The ITC report was released in November 2003 and can be accessed at: http://www.usitc.gov

[4] For details about the extent of the crisis in the T&D industry, see Bruce Stokes's article in the *National Journal* of November 15, 2003.

rendered obsolete the skills and competencies accumulated in the industry for several years? Could it be a result of their organizational and managerial ineptitude, arising from failure to develop new organizational capabilities that are appropriate for emerging patterns of competition?

Explanations of the decline of manufacturing in the United States have focused mainly on macroeconomic variables such as the ineffectiveness of the country's technology policy (Lawrence, 1990, Starr and Ullmann, 1988), deteriorating technological capabilities (Tyson, 1988), and "head-to-head competition" from foreign producers (Thoruw, 1993).[5] While some of these explanations apply to the machine tool industry, they gloss over the fact that competitive conditions also vary significantly by sector, industry, and region. Policy effectiveness for promoting competitiveness in individual industries and activities requires that macroeconomic explanations be coupled with regional and sectoral analysis of the competitive forces in the manufacturing sector.

This paper uses survey information from over 60 machine-tool enterprises in northwestern Pennsylvania to explore the extent to which two competing paradigms – Creative Destruction and Organizational Ineptitude – explain the decline of the US machine tool industry.[6] The overarching goal of the paper is to investigate whether information from the cluster of tool shops in northwestern Pennsylvania can be used to gain better insights into the decline in the machine tool industry in the United States.[7] Based on interviews, factory tours, examination of company records, and review of

[5] The steel industry is a case in point, where the plight of US manufacturers have been blamed on predatory pricing by Japanese competitors. This macroeconomic approach obfuscates intrinsic firm-level organizational and managerial deficiencies that could be redressed by the reconfiguration of the firm.
[6] Most of these tool shops are located in the Crawford County town of Meadville – a town that has been described by the *National Journal* as the "Tool and Die Source for the World." (see November 15, 2003 edition, p. 3495).
[7] Other major clusters of machine shops in the U.S. are located in Springfield (western Massachusetts), Michigan, Chicago, South Carolina, and California.

secondary information conducted between 2002 and 2004, the paper argues that the decline in the machine tool industry is more a reflection of the organizational and managerial ineptitude of the firms, rather than a case of creative destruction.[8] Specifically, the paper shows that technological change in the machine tool industry has been incremental rather than discrete, and that when technological change is non-discrete, industrial dynamics are driven more by managerial and strategic considerations than by technical change.

The paper is divided into seven sections. Section I is the paper's introduction, while Section II reviews the theories of corporate and industrial change. Section III discusses technological change in the machine tools industry, whereas Section IV analyzes the nature of the competitive pressures in the industry. Section V considers the organizational and managerial capabilities of firms in the machine tool industry, and Section VI focuses on the role of agglomeration and locational advantage in the resilience of the machine tool industry. Section VII is the summary and conclusion of the paper.

II. THEORIES OF INDUSTRIAL AND CORPORATE CHANGE

Economists explain industrial decline on the basis of two paradigms: creative destruction and organizational ineptitude. Creative destruction occurs when a radical technological change wipes out a whole industry, leaving in its trail ghost and shanty industrial towns. Radical technological change typically induces shifts in competitive performance, often

---

[8] This interview-cum-tour approach allowed us to directly observe differences in shop-floor practices, organizational structures, management practices, channels of communication, supervision, etc. Additional information on these companies was collected from the following five local economic development agencies: Northwest Pennsylvania Industrial Resource Center (NWIRC), Northwest Pennsylvania Development and Planning Commission (NW Commission), Meadville Area Industrial Commission (MAIC), Crawford County Development Corporation (CCDC), and Business Retention Technologies (BRT).

favoring new entrants and posing major threats to incumbents.[9] Schumpeter [quoted in Best (1990, p.120)] argues that, in an era characterized by rapid technological change, firms will be disciplined by the threat of obsolescence. The pressures of "creative destruction" engendered by the innovation process induce firms to behave strategically with regard to product design, technology and organization. What keeps firms alive, according to Schumpeter, is their ability to generate new knowledge; to discard old ideas and replace them with new ones. Firms and entrepreneurs do not maximize profit by simply substituting amongst homogeneous factors of production for a given product. They improve their performance by revolutionizing existing product designs, production processes, and organizational forms (Best, 1990, p.120).

The notion of creative destruction has been used to explain the decline in the Lancashire textile industry.[10] Aldcroft (1964, pp. 116-18) attributes the demise of the industry to, among other things, the failure of British manufacturers to adopt ring spinning and automatic weaving, and their general neglect of science and technology. Specifically, British textile mills failed to take advantage of an important technological change that occurred at the turn of the 20th century. In 1911, a German engineer invented the shuttle-less loom.[11] As the pioneer of textile technology, one would have expected Lancashire textile mills to scramble for this invention, with the intention to maintain their technological leadership. To the contrary, a small German firm purchased the patent for this invention, which it subsequently sold to Sulzer Brothers – a leading Swiss textile-

[9] It is generally known that incumbents are often complacent and slow at responding and adapting to technical change. The dominance of the biotechnology industry by small start-up firms is a manifestation of the failure of the established pharmaceutical companies to play a leadership role in the biotechnology revolution.

[10] From the 1870s, most British industries began to lose their technological leadership to competing industries in Germany and the United States.

[11] Shuttle-less looms have become the looms of choice in the modern textile industry.

equipment manufacturer. Between 1933 and 1953, Sulzer focused on the development of the new technology, which culminated in the introduction of the cutting-edge projectile weaving machine. Thus, with the rise of low-cost producers in the Asia and the Far East, and their loss of technological superiority, the Lancashire mills became history.

The second explanation for industrial decline is organizational ineptitude, arising from the inability of firms to recognize the competitive forces that they face; evaluate their capabilities, and then respond effectively to those competitive forces. In his classic article on the forces of competition, Porter (1979) identifies the five forces of competition as: the threat of entry, powerful buyers and sellers, the threat of substitute products or services, and competition from firms in the industry. Porter contends that firms are unlikely to survive these competitive forces unless they think strategically and identify segments of the industry in which their capabilities are most suitable.

The ability to recognize competitive forces and to position the firm strategically in the market is not a trivial matter. In what has become known as the "capabilities theory" of the firm, Chandler (1977) contends that firms must compete *functionally* and *strategically* in order to survive in a competitive environment.[12] Functional competition involves the introduction of new products and processes, the discovery of new markets and cheaper sources of raw materials. Strategic competition involves diversifying into more profitable areas of production and pulling out from declining areas. Of all the capabilities required to compete functionally and strategically, Chandler argues that those embodied in the human capital of the firm (particularly those who manage the firm) are very crucial. Chandler (1977) attributes the loss of international competitiveness of

[12] For other relevant insights on the capabilities theory, see Nelson and Winter (1982), Langlois (1993), Fujimoto (1998), and Peteraf (1993).

British firms to their failure to make the three-pronged investment in production, distribution, and management. They thus remained small-scale family firms and therefore were unable to develop the organizational capabilities necessary to compete functionally and strategically.

In her classic book, Penrose (1959) argues that the performance of firms depends on “internal and external inducements,” Internal inducements arise from the excess accumulation of managerial and administrative resources, as well as experience. Firms imbued with these excess resources tend to diversify into related areas of production, and thus enjoy the economies of scope. External inducements arise from new demand conditions, or the availability of new knowledge and productive resources. According to Penrose, firms tend to grow in response to these external inducements. One interesting inference from the Penrosian approach is that industrial dynamics will be characterized by the transformation of firms into larger sizes in this era of rapid technological change. This transformation, she further argues, will be driven mainly by firms responding to external inducements created by new production opportunities and the availability of new knowledge. In the next section, I show that technological change (and its concomitant creative destruction) is not primarily to blame for the decline of the US machine tool industry.

III. TECHNOLOGICAL CHANGE IN THE MACHINE TOOL INDUSTRY

For a long time, the technological basis for tooling and precision machining was the Numerical Control (NC) milling and grinding machines. These were manually operated machines that were widely used in the tooling industry during the post WWII era. Rising wage rates in the industrial world in the post-war years, however, induced a labor-saving technological change that resulted in the introduction of Computer Numerical Control (CNC) machines.[13] The CNCs are programmed to replace many of the labor-intensive tasks associated with NC machines, and as long as they are programmed correctly, the possibility of human error is also minimized.

The U.S. machine tool industry was initially very slow at adopting these new technologies – a mistake that led to their loss of market shares to fully-automated machine shops in Japan (Stokes, 2003, p.3406).[14] With the recovery of the U.S. economy in the mid 1980s, as well as the threat from the Japanese, there was a widespread adoption of the new technology in the U.S. machine tool industry in the late 1980s.

The introduction of CNC machines, however, did not pose a major threat to the US tooling industry. Although the CNC machines are more capital-intensive, the skill requirements for both the NC and CNC machines remain basically identical. Toolmakers that were trained during the era of NCs had no difficulty switching to CNCs. Apart from the cost of the new machines, the tooling firms incurred little or no switching costs from moving to CNCs. The skills required to program CNC machines typically can be learned on the job or outside the shopfloor at a minimal cost. In other words, there was no "creative destruction" arising from technological change in the US machine tool industry. For technological change to creatively destroy, it must exhibit the following features, none of which occurred in the machine tool industry:

[13] Wage growth during the 1940-1970 period was three times higher than the period of 1970-2000 (Kaboski, 2004, p.12).
[14] Apart from the recession of the early 1980s, which resulted in cash flow problems that made it difficulty for U.S. machine shops to purchase new equipment, tool-shop owners were reluctant to dispense with the highly skilled toolmakers in their employment. The cluster of tool-shops in northwestern Pennsylvania prides itself as the bastion of experienced and highly skilled toolmakers and dreaded the fact that automation would result in the loss of this capability.

1. Competence-Destroying: One reason the factory system in C18th Britain was creatively destructive during the industrial revolution was that it required substantially new skills for operating, monitoring, and maintaining spindles and looms. Not having those skills, the artisans who spun and wove cotton at home became either unemployed or forced to become mere factory hands – a phenomenon that destroyed the traditional textile industry in Britain. Contrariwise, the introduction of CNC and EDM machines did not induce a major change in the skills required in the US machine tool industry. The entry qualifications into the tooling profession continues to be the same for both the NC and CNC machines.[15] In other words, the introduction of CNCs represents what Beiji (1998, p.140) refers to as an "architectural innovation." In his words, an architectural innovation has " the same core technology as the old product and its is not immediately clear that product performance depends on new linkages between some components, which require quite a different technological expertise from the old product." (Beiji, 1998, p.140).
2. Complexity of Scientific Knowledge: The new technology must embody a more complex scientific knowledge than the old one. In the pharmaceutical industry, for instance, the emergence of biotechnology diminished the role of the in-house researchers at the pharmaceutical companies. Much of pharmaceutical R&D was shifted to the small, start-up biotech firms with competence in the manipulation of the genetic structure of cells to induce them to produce therapeutic compounds. According to Pisano (1990, p.155), "biotechnology represented a competence-

[15] The normal training trajectory for a toolmaker with a high school diploma is a couple of years of training at a vocational school and two to three years apprenticeship at a tooling company.

destroying technology because it required technical skills that were fundamentally from those with which established pharmaceutical firms were familiar.

3. Destruction of Existing Market: The introduction of computers can be regarded as a case of creative destruction in many respects. For instance, the market for typewriters was destroyed by word processors. The introduction of digital photography has destroyed the extant market for film-based photography, resulting in a serious threat to the survival of Kodak.

The upshot of the preceding considerations is that technical change in the machine tool industry had none of the above effects, and hence could not have been a major cause of the decline of the industry. Rather than destroying tool shops, incremental technical change offers opportunities for these firms to strengthen their competitive abilities. As Jones (2003, p.1267) points out, operating in an industry characterized by incremental technological change induces firms to enhance the price performance attributes of their products – attributes that are critical for overcoming the competitive pressures from low-cost foreign competitors. Additionally, firms could use the basic technology to churn out new product lines that attract new users.[16] During interviews with tool shops in northwestern Pennsylvania, not a single shop mentioned technological change as a pernicious problem.[17] Indeed, many of the shops admitted that technological change has

[16] With intense competition from cheap imported tools, US tool shops ought to use their competence, skills, and experience in tool-making to create unique product lines that are less vulnerable to competition.
[17] However, the smaller shops mentioned the problem of lack of money to purchase expensive CNC machines.. Thus, the problem is not the lack of capabilities for using the machines, but one of finding money to buy the equipment.

enabled them to narrow the cost differences between them and their Chinese competitors.[18]

If technological change is not responsible for the rapid decline of the machine tool industry, the alternative hypothesis to be explored is the organizational and managerial ineptitude of the tooling companies. I show in subsequent sections that the failure of US machine tool companies to develop the organizational capabilities to respond to competitive pressures is largely responsible for the decline of the industry. The organizational structure of the tool shops in the United States evolved to address the nature of the competitive environment during the early days of the industry. However, these shops have failed to invest in new organizational capabilities that are appropriate for emerging patterns of competition. To understand why and how organizational and managerial deficiencies have undermined the competitiveness of the machine tool industry, one must first review the contemporary forces of competition in the industry.

IV. COMPETITIVE PRESSURES IN THE US MACHINE TOOL INDUSTRY

As will be shown in the next section, the U.S machine tool industry was built on a culture of "guaranteed jobs" and patronage by its customers. The notion of "cut-throat" competition among firms in the same cluster was very unusual. However, the machine tool industry has come under unprecedented competitive pressures in recent times.[19] Those competitive pressures are reminiscent of the ones identified by Porter (1979). In

[18] With wages averaging between $18-$20 an hour in the U.S. machine tool industry, automation was seen as a relief to the spiraling wage bills of the tool shops.
[19] During interviews with tool-shop owners, they expressed surprise at the intensity of the current competitive pressures. They recalled that decades ago, when the Japanese used to be their major competitors, the intensity of competition was not close to what it is today.

his seminal article on the forces of competition, Porter identifies the following sources of competitive pressures: Threat of Entry, Powerful Suppliers and Buyers, Substitute Products, and Jockeying for Position Among Current Competitors.

Threat of Entry: Entry into the machine tool industry is relatively easy. Many tool-shop owners start with a couple of used and very cheap NC machines that are installed in the basement of their homes. Initial overhead capital is typically low, as is sunk costs. The owners often use their property and family labor to run the business. Quite often, owners of new shops keep their main jobs at a major tooling company in the process of developing their own business. The ease of entry has ensured a steady influx of new firms into the machine tool industry, resulting in overcapacity in the industry. For instance, there are over 7000 mold makers in North America, serving just two major customers – Tyco and Delphi.

Powerful Buyers: Another competitive pressure encountered by the tooling shops is the increasing exercise of market power by the customers of the industry.[20] These customers are imposing conditions that affect the profit margins of the firms. For instance, they are extending the usual payment period for goods supplied from 60 to 90 days, resulting in cash-flow problems for the tooling companies. Cashing in on the desperation of the firms, the customers are also demanding that the firms cut their prices by as much as 30 percent (Stokes, 2003, p. 3494). Companies that fail to cut their prices lose customers to other shops in this very fragmented industry. Lastly, the tooling companies are being asked by

[20] Two customers – Tyco and Delphi – account for over 80 percent of the demand for tooling in Northwest Pennsylvania.

their major customers to be “ISO certified” – an elaborate and costly quality control program that is often beyond the capabilities of the very small companies. Non-ISO certified firms are being told by their customers that they will not get jobs in the future.

Substitute Products From Foreign Competitors: The source of foreign competitive pressures is not from imports *per se*. In fact, US imports of tools, dies, and molds fell from about $2 billion in 1997 to $1.7 billion in 2001. The problem is that the customers of the tooling companies (such as Delphi and Tyco) now find it cheaper to source their tooling needs from abroad, especially China and Mexico. They do this by moving some of their production facilities to these countries. Foreign competition has been more intense in molding and less so in precision machining and spare tooling. It is no secret in the industry that the Chinese can build a mold for just one-third of the cost of a mold built in the United States. According to a *Wall Street Journal* report of August 25, 2003, p. A2, “some imported automotive parts are being sold for less than the cost of raw materials needed to make them.” Some of the reasons for the cost disadvantage of the US firms include high premiums for health insurance and high wage bills.

Jockeying for Position Among Current Competitors: Squeezed by foreign competitors and a steady stream of new domestic entrants, firms in the machine tool industry struggle to maintain their dwindling market shares. They do so by cutting prices (sometimes below average cost), acceptance of unfavorable payment conditions from customers, and by offering new services to their customers. In addition to the Porter-type competitive pressures, firms in the industry also face the following pressures:

Escalating Costs of Health Insurance: Nearly all the companies surveyed for this study referred to escalating health-care costs as a major source of competitive disadvantage.[21] The health insurance premium for a toolmaker with a family costs about $600 per month; a shop with 50 workers would have to pay over $300,000 per annum in premiums. Contrariwise, the Chinese and Canadian tooling companies are not required to provide medical care for their workers; medical care is available free-of-charge under the single-payer system. For details about the impact of foreign competition on the machine tool industry in the United States, see the ITC report.

Lack of a "Level Playing Field": Most of the tool-shop owners interviewed complained about the lack of a 'level playing field' between them and their Chinese competitors. They claim that the Chinese government subsidizes Chinese firms in ways that undermine the competitiveness of U.S firms. For instance, the Chinese government is said to be in the habit of deliberately undervaluing the Chinese currency, the result of which is that exports from China are cheaper and imports more expensive. Chinese companies are also not required to conform to environmental regulations, saving them from those costs that are typically incurred by American manufacturers. As noted earlier on, Chinese companies do not provide medical care for their workers. Asked whether the U.S government should impose high tariffs on molds and tools from the Chinese to 'level the playing field', the shop owners differ in their views. While many support higher

[21] Andover Industries, a manufacturer of molded plastic parts for the auto and consumer goods industries, closed its plant in Meadville, Pennsylvania in April 2005 mainly because of high health insurance costs (see The Meadville Tribune, February 2, 2005, pp A1 and A6).

tariffs, others suggest that the Chinese government should be forced to remove the subsidies that it provides for Chinese manufacturers.

Why have US toolmakers failed to respond to competitive pressures? Porter argues that firms need to do two things in order to overcome competitive pressures. First, they must recognize the existence and sources of competitive pressures. Second, they must identify and invest in areas of the industry that are less susceptible to competition. The latter strategy may require the firm to exit completely from a contentious segment of the market and to invest a niche segment. But the ability to recognize competitive pressures, and respond to them effectively depends on the organizational and managerial capabilities of the firms – assets that are grossly lacking in the US machine tool industry.

V. ORGANIZATIONAL INEPTITUDE AND THE DECLINE IN U.S. TOOLING INDUSTRY

The preceding section has shown that there is a broad array of competitive pressures stacked against tool shops in the United States. The hypothesis of this paper is that, a shift in competitive performance in the absence of a radical technological change suggests intrinsic managerial and organizational problems at the level of the firm. In this section, I explore the nature of the managerial and organizational problems encountered by the tool shops.

The dominant organizational structure in the machine tool industry is what can be referred to, for lack of a better term, as an “insular” structure. This is an organizational structure in which the shop owner is not only the sole residual claimant, but the enterprise itself exists to serve one or two *known* customers. In other words, an “insular” organizational structure is one devoid of all competitive attributes. The firm's organizational culture, routines, and *modus operandi* evolved as if it were "insulated" from competition – hence the label "insular organizational structure."

The pervasiveness of the insular organizational structure in the industry is not fortuitous, and can be best understood in the context of the competitive environment that existed at the early stages of the industry.[22] Such an understanding requires a brief detour into the evolution of the machine tool industry, especially in northwestern Pennsylvania.

Tool shops in northwestern Pennsylvania owe their origin to the Talon Zipper Corporation that was established in Meadville in the 1930s. As an integrated company, Talon also manufactured molds that made parts for its zippers. During World War II, Talon exploited its economies of scope by using its competence in zippers to manufacture spare parts for the US military. Following the spate of vertical disintegration in the automobile and electronics industries in the post-World War II era, Talon further diversified into making molds and parts for these industries. Through an elaborate apprenticeship program, Talon trained a coterie of toolmakers who were subsequently employed by the company as journeymen and supervisors. Because Talon was unable to keep-up with the huge demand from the automobile and electronics industries, it developed a culture of contracting out some of the jobs to its workers, who in turn did those jobs in the basement of their homes during their leisure times.[23] Over time, some of these "worker-contractors" found that they were making more money working as

[22] As a general rule, organizational choice reflects the strategic and operational exigencies that the firm has to deal with. As Drucker points out (1998, p.5), "[T]here is no such thing as the one right organization. There are vast differences in organizational structure according to the nature of the task."
[23] These workers were still employed full-time by Talon and considered the contracted or "farmed-out" jobs as extra income. This is another manifestation of the Druckerian notion that firms often change their organizational structures in response to pragmatic business conditions.

contractors than as wage earners. They subsequently decided to establish their own independent shops, with almost all their jobs coming from Talon. Talon, in turn, found it more cost-effective to subcontract jobs to its former employees, whose skills, reliability and trust it could count on.

Not surprisingly, therefore, the organizational structure that emerged in the local machine tool industry was one geared toward meeting Talon's demands. The now-independent toolmakers did not have to compete with one another to obtain jobs from Talon. Given the little capital investment required to establish a tool shop at that time, the organizational structure was necessarily sole proprietorship – although there were a few instances when friends formed partnerships. The sole owner – the toolmaker – was responsible for making all the decisions, as well as taking charge of all the functional areas of the organization (production, marketing, finance, and administration). The key to competitive success was the owner's personal contact with Talon. In other words, seeking and nurturing new customers was not the raison d'*etre* of the organizational structure of the tool shops. When Talon moved from Meadville to South Carolina in the 1980s, its customers began dealing directly with the new tool shops – a situation that made business even more lucrative for the shops. As business boomed in the 1960s and 1970s, these shops began their own apprenticeship programs where a "second generation" of toolmakers were trained. Brazing Talon's path-dependent trail, the 'first generation" toolmakers began subcontracting jobs to their own workers – a practice that also culminated in the second generation toolmakers establishing their own shops.

The upshot of the preceding historical detour is to establish the fact that the organizational structure of the machine tool industry was predicated on the paternalistic relationship between the tool shops and their customers. The culture of the industry is one of sharing jobs within a given cluster of tool shops.[24] It was neither an organizational structure designed for competing for jobs, nor one for generating new products. It was simply an organizational structure designed for "machining" whatever product design that tool-shop customers wanted. This organizational choice was relatively efficient, so long as the customers continued to "guarantee" jobs for the tool shops.

However, as section IV shows, the competitive environment began to change in the late 1990s. Jobs were no longer guaranteed by the large customers, which in turn created a cascading effect whereby the bigger shops could no longer contract jobs out to the smaller shops. Given the mismatch between the extant organizational capabilities of the shops and the emerging competitive environment, pragmatism and strategic considerations require that they jettison this anachronistic structure. A preponderance of the tool shops, however, still adhere to the post World War II managerial and organizational mind-set – one that is based on guaranteed orders, patronage, and lack of competition.

The survey of the tool shops in northwestern Pennsylvania indicates, at least anecdotally, that there is a correlation between organizational choice and performance. Appendix A shows the list of the firms surveyed, divided into successful and unsuccessful firms.[25] Notice from the appendix that the successful shops are larger in

---

[24] Shop owners within the northwestern Pennsylvania cluster don't view one another as competitors as such. They rather see their competitors as those located in other clusters.

[25] The successful firms are those that were unanimously identified by their peers as very successful. One remarkable feature of the machine-tool cluster in northwestern Pennsylvania is that the shops know each other. Information flows very freely within the cluster, and everybody knows who is down and who is up. The opinions of the peers were corroborated by my interviews of the successful companies. The unsuccessful firms are those that closed down during the period 2002-2004. They were selected from the *Business Calling Database* maintained by the Meadville Area Industrial Commission.

size (as measured by the number of employees and sales) than the unsuccessful firms.[26] All of the unsuccessful shops were very small companies, both in terms of employment and sales. About half of them employed two persons or less, while none of them employed 10 or more workers. Annual sales for the majority of the unsuccessful firms were less than $250,000. Surprisingly, most of the shops were established several years ago, and their owners had considerable experience in the industry. Only six of the unsuccessful companies were established less than 10 years ago, suggesting that length of operation and experience have little to do with performance in the tooling industry – an observation that that gives further credence to the role of organizational capabilities.

Although the correlation between size and success may not be conclusive evidence about the salience of organizational capabilities, it is surely suggestive. During interviews and visits to the firms, it was found that nearly all of the successful shops had shed the insular organizational structure that is typical in the industry.[27] Most have adopted the U-form organizational structure, with functional units (marketing, human resources/administration, and production) that are headed by family and non-family members.[28] The correlation between size and organizational structure should not be surprising because firm size has decisive influence on both organizational behavior and organizational boundary decisions (Scherer, 1980; Miles, 1980). Unlike the insular organizational structure where the owner makes all the decisions, the owner of the typical

---

[26] The mean number of employees for the successful firms was 52 compared to 8 for the unsuccessful firms. Sales averaged $3.7 million for the successful companies relative to $523,000 for the unsuccessful firms.
[27] Forrant and Flynn (1999) found that a Springfield, Massachusetts machine tool company that turned itself around from failure to success did so after the firm was completely reorganized.
[28] Most tool shops in northwestern Pennsylvania contract out their accounting and legal functions to outside firms.

U-form firm holds daily meetings with the heads of the functional units.[29] The market outlook is reviewed during each meeting, and decisions are made collectively about how to fill existing orders and how to allocate human and material resources. In other words, the meetings tend to focus on operational rather than strategic issues. Although the U-Form organizational structure delegates some powers and responsibilities to the functional heads, the shop owner still retains the power to make strategic decisions – including whether to diversify, to export, to layoff or hire new workers, or to invest in a new technology.

Assuming that the observed relationship between organizational choice and performance in the sample firms is not spurious, it implies that the age-long insular organizational structure in the machine tool industry may be a drag on the competitiveness of the industry. While routines and path-dependency have been touted as veritable sources of dynamic capabilities (Nelson and Winter, 1982), they can unwittingly lead to the accumulation of anachronistic capabilities. As the historical experiences of the tool shops in northwestern Pennsylvania have shown, routines may lock a firm into an “insular” organizational structure that circumscribes its ability to compete effectively in a new business environment.

Because of the "non-compete," non-aggressive, “be-thy-neighbor’s” keeper’s nature of the organizational structure of U.S. machine shops, they have been reticent in adopting some of the modern tools of management. The result is the following managerial deficiencies that have undermined their capacity to respond to competitive pressures:

---

[29] For details about the U-Form organizational structure, see Onyeiwu (2000) and Coombs, et al. (1987, p.36).

1. *Poor Managerial Skills*: Most of the tool shops in northwestern Pennsylvania have not been able to leverage their technical and entrepreneurial skills into distinctive products that would give them competitive advantage. Many of them do not know how to read a balance sheet, which has in turn resulted in their inability to track costs and revenue in a systematic way.[30] Most of them rely on outside accountants, who have little or no knowledge about the intricacies of tool making. Some shop owners even lack information on basic items such as overhead costs, number of machine and labor hours available, machine and labor time required for a given job, and how much it costs to make individual products. Many tend to lump their costs together, without separating them into the various products. In the words of one experienced toolmaker with knowledge of the local shops: 'Toolmakers don't know where their costs are. They don't know how to determine wins and losses, and they cut too much into their profits in order to get a job'. Very few shops undertake 'machine analysis' to determine whether to use labor-intensive or more automated equipment for a given job. Consequently, shop owners tend to "under quote" their products, resulting in losses for many shops. The tendency to under quote has also been worsened by the stiff competition in the industry –both from local and foreign competitors.
2. *Lack of Core Competencies:* The ability to distinguish oneself from other shops appears to be a very important determinant of success (Onyeiwu, 2003). Some shops have distinguished themselves by focusing on niche markets such as precision grinding, precision machining for high-tech industries (such as

[30] Of all the problems that small enterprises encounter, the lack of management skills is often isolated as a pernicious dilemma. Kilby (1988) refers to this as the 'mere-management' hypothesis, which analysts such as Liedholm and Parker (1989, p. 28) argue does not have persuasive empirical evidence.

aerospace and medical equipment), Research & Development (R&D), specialty tooling, etc. Successful companies have also distinguished themselves through quick delivery, quality and reliable products, effective after-sales service, and by offering ‘full service’ to their customers. The majority of the companies, however, have failed to differentiate their products from those of their rivals, resulting in stagnating sales and loss of market shares.

3. *Lack of Strategic Planning:* Most of the tool-shops that encountered severe difficulties had neither a business plan, nor a strategy for dealing with economic crisis and competitive pressures. The ability to forecast the future trends of the industry is key to the survival of tool shops. Shops that projected a rough business climate a few years ago were able to make the necessary adjustments needed to weather the storm. Adjustments have included diversification (adding production to mold-making, for instance), lean manufacturing, investment in R&D, pulling-out of declining areas to niche markets such as precision machining and specialty products. One former shop owner said he foresaw the looming crisis in the machine tool industry in 1998 and decided to sell his company. Another owner who envisaged an impending decline in the industry moved into the production of high-pressure cooling equipment.
4. *Inability to Adapt or Diversify:* The ability to respond to changes in the business environment is an important determinant of success in the machine tool industry. The companies that went out of business, or struggled to survive, were those that continued to do business the old way. These companies typically depend on one or two customers (such as Tyco and Delphi); they produce the same products that

they have been producing for the past 20 years or so; and often do not utilize the various resources provided by the local economic development agencies. These resources include management training, consulting services, market research, information technology support, environmental services, succession planning and strategic planning. Successful shops, on the other hand, tend to think ‘outside the box’, often adding new product lines and aggressively seeking new customers both in the United States and abroad. Some successful shops have even teamed up with Chinese tooling companies to take advantage of their low production costs. While the Chinese provide cheap labor, the local shops provide expertise that the Chinese are lacking. This way, the companies are able to retain their American customers (such as Tyco and Delphi) by offering them high-quality product at low costs. One local shop owner spent $12,000 for a recent trip to China in search of partners. Successful shops have also used their excess capacity to diversify into production and R&D.

VI. ECONOMIES OF AGGLOMERATION, LOCATIONAL ADVANTAGE, AND THE RESILIENCE OF TOOL SHOPS

Despite unprecedented competitive pressures in the industry, the enterprises surveyed have been surprisingly resilient. Firms in the northwestern Pennsylvania cluster seem to have done relatively better than their counterparts in the other clusters.[31] The survey

[31] According to the *Business Calling Database* maintained by the Meadville Area Industrial Commission (MAIC)and information from the Northwestern Pennsylvania Industrial Resource Center (NWIRC), about 25 (out of nearly 157) tool shops went out of business in Crawford County during the past three years or so (see Appendix A for the list of the closed shops). This represents a closure rate of 15.9 percent – about half the national rate. The closed shops employed a total of 115 workers, which represents the number of jobs lost permanently by the county in the machine tool industry. In other words, the county has permanently lost about 3 percent of the workforce in the. However, the county lost fewer jobs in the industry compared to the national average. Whereas an average of 10 jobs were lost per tooling shop nationally, the county lost only 6 jobs per shop.

suggests that many shops have been helped by the economies of agglomeration that firms enjoy by virtue of their being located within the same industrial cluster. In other words, the decline of the machine tool industry could have been worse, were it not for the following economies of agglomeration:

1. *Low Overhead Cost*: Tool-shops in Northwest Pennsylvania enjoy a relatively low overhead cost, compared with their counterparts in other regions. Many shops are located on the personal property of the shop owners, and family labor is frequently used in running the business.
2. *Strong Bonds between Owners and Employees*: Owners and employees regard themselves as members of the same family. In good times, they share the windfall gains from business. In turbulent economic times, the workers are also willing to make sacrifices to ensure the survival of the shops. Workers have been willing to take a pay cut, work shorter hours, and accept fewer benefits.
3. *Attachment to the Community*: Most shop owners and toolmakers were born and raised in the community. They attended area high schools, went on to the local vocational technical school, and then ended up as apprentices in the local tooling shops. In other words, their entire lives have been spent in the region, and they are reluctant to move away this late in their lives. Thus, they make any sacrifice that would ensure that they remain in the community.
4. *Interdependence Among Area Shops*: The close proximity of competitors may enhance their collective competitive abilities. In the words of Chung and Kalnins (2001), “competitors that agglomerate, that are physically proximate, may create

externalities – production efficiencies or heightened demand that increases rent." Tooling shops in Crawford County of Northwestern Pennsylvania are reputed for the high level of cooperation that exists between them. It is not uncommon for shops with large orders to "farm" out jobs to less fortunate shops. In fact, some small shops depend solely on other shops for jobs and survival. Equipment sharing is also common among the tool shops, with firms that own cutting-edge technologies allowing smaller firms access to those technologies.

5. *Support From the Local Economic Development Agencies*: The impact of competitive pressures on the machine tool industry appears to have been cushioned by support from the local economic development agencies. The agencies include the Northwest Pennsylvania Development and Planning Commission (NW Commission), the Northwest Pennsylvania Industrial Resource Center (NWIRC), the Meadville Area Industrial Commission (MAIC), and the Crawford County Development Corporation (CCDC).[32]

[32] The NWIRC, for instance, recently helped a major tooling company in the area to avoid closure. Through the management and consulting assistance provided by the NWIRC, the company filed for bankruptcy and is in the process of emerging from Chapter 11.

VII. SUMMARY, CONCLUSIONS AND POLICY RECOMMENDATIONS

This paper has explored whether the decline in the U.S. machine tool industry is attributable to creative destruction or organizational ineptitude. The paper finds no support for the notion that creative destruction is to blame for the poor performance of the industry. First, technological change in the machine tool industry has been incremental and non-discrete, requiring no new skills in the industry. Second, firms in the industry have adapted very well to technological change.

The paper, however, finds significant organizational and managerial dilemmas in the industry. Given the new competitive environment that firms in the industry face, the age-long "insular" organizational structure that evolved in the industry has become anachronistic. The paper finds anecdotal evidence that firms that jettisoned this organizational structure have been more successful at responding to competitive pressures. It would seem, therefore, that American tool shops face the same dilemma encountered by British firms during the last quarter of the 19th century – the failure of the latter to invest in the organizational capabilities that would enable them to compete functionally and strategically (Chandler, 1992). Given the new competitive environment, tool-shops that conduct business "the old way," and thus fail to behave strategically and functionally are unlikely to respond effectively to competitive pressures. In other words, successful response to competitive pressures requires deviation from routines and path dependency.

The paper concludes that the ability of U.S. machine-tool shops to response effectively to competitive pressures has been limited by their lack of knowledge of the basic tools of management. These include the ability to read and interpret a balance sheet, to determine the optimal use of machine and labor hours, to monitor the cost of producing individual products, and the ability to choose the optimal prices for products. Success also requires the development of core competencies, the ability to behave strategically by divesting from more contentious segments of the market, and investing in new products, services and R&D. Larger enterprises with non “insular” organizational structures were found to be more successful at responding to competitive pressures.

REFERENCES

Aldcroft, D.H. 1964. “The Entrepreneur and the British Economy, 1879-1914,” *Economic History Review*, August: 116-18 and 121-23.

Beiji, P. 1998. *Technological Change in the Modern Economy*. Cheltenham, UK: Edward Elgar.

Best, M. 1990. *The New Competition: Institutions of Industrial Restructuring.* Cambridge, MA: Harvard University Press.

Chandler, A.D. 1977. *The Visible Hand: The Managerial Revolution in American Business*. Cambridge: the Belknap Press.

Chandler, A.D. (1992). “Organizational Capabilities and the Economic History of the Industrial Enterprise,” *Journal of Economic Perspectives,* 6(3): 78-100.

Chung, W. and Kalnins, A. 2001. “Agglomeration Effects and Performance: A Test of the Texas Lodging Industry,” *Strategic Management Journal,* Volume 22, Issue 10, 969-988.

Coombs, R. Saviotti, P. and Walsh, V. 1987. *Economics and Technological Change.* Totowa, NJ: Rowman & Littlefield.

Drucker, P. (1998). “Management’s New Paradigms,” *Forbes*, Vol.162, Number 7.

Forrant, R. and Flynn, E. 1999. "Skills, Shop Floor Participation and the Transformation of Brimfield Precision, Inc.: Lessons for the Revitalization of the Metal-Working Sector," *Industrial and Corporate Change,* 8, 167-88.

Fujimoto, T. 1998. “Reinterpreting the Resource-Capability View of the Firm: A Case of the Development-Production Systems of the Japanese Auto-Makers,” in A.D Chandler, P. Hagstrom and O. Solvell (eds), *The Dynamic Firm.* Oxford: Oxford University Press. 15-44.

Kaboski, J.P. 2004. “Education, Sectoral Composition, and Growth,” Working Paper, Department of Economics, Ohio State University.

Kilby, P. 1988. “Breaking the Entrepreneurial Bottleneck in the Late Developing Countries: Is there a Useful Role for the Government?” *Journal of Development Planning* 18.

Langlois, R.N. 1993. “Capabilities and Coherence in Firms and Markets,” Paper Presented at the Conference on Evolutionary and Resource-based Approaches to Strategy, Copenhagen, August 27-29.

Lawrence, R.Z. (1990). "Innovation and Trade: Meeting the Foreign Challenge," in H.J. Aaron (ed), *Setting National Priorities: Policy for the Nineties,* Washington DC: Brookings Institution.

Liedholm, C. and Parker, J. 1989. "Small Scale Manufacturing Growth in Africa: Initial Evidence," USAID Working Paper.

Miles, R. 1980. *Macro Organizational Behavior,* Santa Monica, CA: Goodyear.

Nelson, R.R. and Winter, S.G. 1982. *An Evolutionary Theory of Economic Change.* Cambridge, MA: Harvard University Press.

Onyeiwu, S. 2000. Technological Strategies of Leading Firms: the Case of the BICC Group," *Technology Management*, Vol. 10, No. 3, 87-102.

Onyeiwu, S. (2003). "Some Determinants of Core Competencies: Evidence from a Binary-Logit Analysis," *Technology Analysis & Strategic Management,* Vol.15, No.1: 44-63.

Penrose, E. 1959. *The Theory of the Growth of the Firm.* Oxford: Basil Blackwell.

Peferaf, M.A. 1993. "The Cornerstones of Competitive Advantage: A Resource-Based View," *Strategic Management Journal,* 14, 179-191.

Pisano, G.P. 1990. "The R&D Boundaries of the Firm: An Empirical Analysis," *Administrative Science Quarterly,* 35: 153-176.

Porter, M.E. 1979. "How Competitive Forces Shape Strategy," *Harvard Business Review,* March-April.

Scherer, F. 1980. *Industrial Structure and Economic Performance,* Chicago: Rand McNally.

Sharpe, A. (1999). "New Estimates of Manufacturing Productivity Growth for Canada and the United States," Paper Prepared for the Meeting on the Research Advisory Committee on the CSLS Project on the Canada-U.S. Manufacturing Productivity Gap, Chateau Laurier, Ottawa, March 25.

Starr, M.K. and Ullmann, J.E. (1988). "The Myth of U.S. Industrial Supremacy," in in M.K. Starr (ed.), *Global Competitiveness – Getting the U.S. Back on Track,* New York: W.W. Norton.

Stokes, B. (2003). "There Is No Joy in Meadville," *National Journal,* November 15.

Thurow, L. (1993). *Head to Head Competition: The Coming Economic Battle Among Japan, Europe, and America*, New York: Warner Books.

Tyson, L.D. (1988). “Competitiveness: An Analysis of the Problem and a Perspective on Future Policy,” in M.K. Starr (ed.), *Global Competitiveness – Getting the U.S. Back on Track,* New York: W.W. Norton.

APPENDIX A

			UNSUCCESSFUL COMPANIES			
COMPANY	AGE	SIZE	PRODUCT TYPE	LOCATION	ANNUAL SALES	INFRASTRUCTURE
AC Machine&Mfg. Co.	21	6	0	1	<500000	9
Absolute Tool & Mold	13	7	0	1	<500000	9
Centennial Tool Mfg.	28	1	1	1	<500000	9
Toolex Systems Inc.	14	4	0	1	<500000	9
Frontier Foundry Inc.	4	50	0	0	1000000	12
Beck Tool Company	14	7	1	0	500000	11
ALB Inc.	14	1	0	0	<500000	15
Corgren/Power Systems	16	18	0	0	1000000	15
Gillespie Machine & Tool	65	11	0	0	500000	15
Hall Precision Tool&Die	10	6	0	0	500000	9
Kerner Tool and Die	11	25	1	0	1000000	15
McDanniels Machine Co.	44	8	0	0	500000	15
S&S Speciality Tool	13	6	0	0	500000	13
Aggressive Forge Die Co.	29	4	0	0	<500000	15
Advanced Tech Machining	17	1	0	0	<500000	6
Magnum Machine Co.	50	25	0	0	1000000	12
Custom Tool & Mold	36	1	1	1	<250000	15
Lightning Plastics	4	1	1	1	<250000	15
Spark Tool, Inc.	14	6	0	1	500000	15
CAM Tech	7	1	1	1	250000	15
Diversified Tool Corp.	29	4	1	0	500000	11
Green's Tooling	17	1	0	0	<250000	9
Infinity Tool and Mfg.	7	2	1	1	<250000	4
Kastle Plastic Injection	<1	2	1	1	1000000	13
Parts, Etc.	3	0	0	1	<250000	15
Repko Tool	10	7	1	1	250000	11
Yarnell Tool	5	1	0	1	<250000	6
United Tool & Die	20	12	1	1	1000000	13
Worley's EDM	~	1	0	1	<250000	13
Kozalla	~	1	0	1	<250000	13
Mal Mor Forge	3	1	0	0	<250000	5
Autoforge	9	28	0	0	1000000	5
			SUCCESSFUL COMPANIES			
COMPANY	AGE	SIZE	PRODUCT TYPE	LOCATION	ANNUAL SALES	INFRASTRUCTURE
Abbatron, LLC	3	35	0	1	2000000	13
Actco Tool & Mfg.	41	34	0	1	1000000	10
Acutec	16	137	0	0	>15000000	11
Advantage Mold	20	10	1	1	500000	13
Aetna Machine Co.	49	14	0	0	1000000	10
Area Tool & Mfg.	28	15	1	1	1000000	25
Bra-Vor Tool & Die	36	13	0	1	1000000	13

ChipBlaster, Inc.	10	30	0	1	>15000000	17
C & J Industries	42	220	1	1	>15000000	15
Czech Tool Co.	10	10	0	0	500000	9
Highpoint Tool	11	34	1	0	1000000	9
Kuhn Tool & Die Co.	41	13	1	1	1000000	17
Laser Tool Inc.	25	20	1	0	1000000	9
Leech Industries Inc.	56	146	1	1	10100000	12
Maloney	15	55	1	1	6100000	12
Micro Tool & Mfg.	35	25	1	1	1000000	17
Multi-Tool	27	33	1	1	1000000	15
Nutec Tooling Syst.	21	45	0	1	1000000	15
Pasco Tool&Plastic	32	25	1	1	1000000	15
PA Tool & Gage	50	62	1	1	5100000	12
Proform Tool Corp.	23	22	0	0	(confidnetial)	15
Sipco Molding Tech.	15	68	1	1	5100000	13
Starn Tool & Mfg.	59	50	0	1	5100000	12
Tech Tool & Mold	31	90	1	1	6100000	13
Viking Tool & Gage	38	112	0	0	5100000	19